Dynamics of Localized Photoexcitations in Condensed Matter Systems: Electron-Phonon Effects in Self-Trapping

Susan L. Dexheimer, Washington State University

CAREER Award DMR-9875765

Localized states play an important role in determining the properties of many electronic materials. A dominant factor in the dynamics of localized states is the interplay between the electronic and vibrational degrees of freedom.

In this work, we are studying the dynamics of localized states in a class of materials in which the strength of the electron-phonon coupling can be systematically varied. By carrying out measurements with light pulses that are short compared with the characteristic vibrations of the material, we can directly time resolve vibrational motions that drive the dynamics.

Using this method, we have for the first time observed the atomic-scale motions associated with the formation of the self-trapped exciton, a localized excitation important in molecular electronic materials. We find that self-trapping occurs on the time scale of a single vibrational period, essentially the fastest possible time scale for a structural rearrangement, and that the formation rate scales directly with the electron-phonon coupling strength.

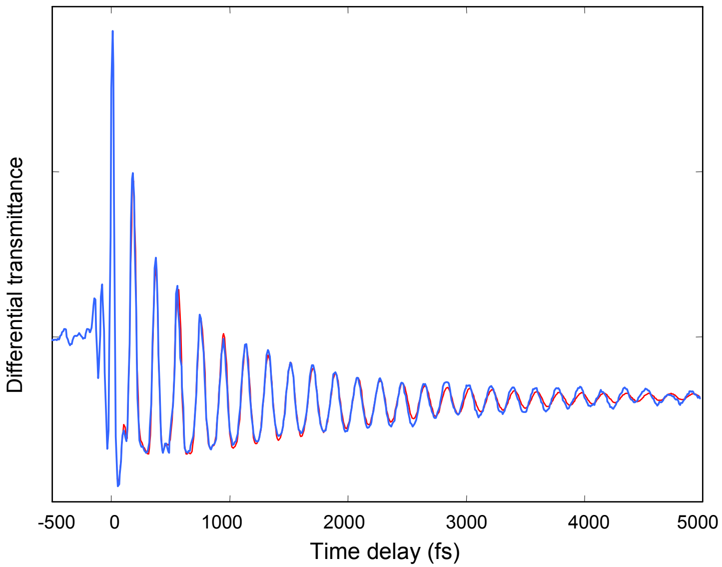

Figure 1. Measurement of the femtosecond optical response of the quasi-one-dimensional molecular solid $[Pt(en)_2][Pt(en)_2Br_2]\cdot PF_6$. The oscillations reflect coherent vibrational motion of the lattice. Analysis of the response reveals a component corresponding to the lattice motion that drives the formation of the self-trapped state.

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Associated educational activities:

Graduate students Aaron Van Pelt, Frances Morrissey, and Chris Dudley, and undergraduate students Susan Richardson, Andreas Gross, and Erin Craig contributed to this research project, receiving interdisciplinary training in condensed matter / materials physics, optical techniques, and scientific research practices.

As part of her CAREER Award activities, the PI has developed laboratory experiments in optical physics, expanding opportunities for undergraduate physics education at WSU. The PI is also engaged in student mentoring activities, with particular emphasis on women students.

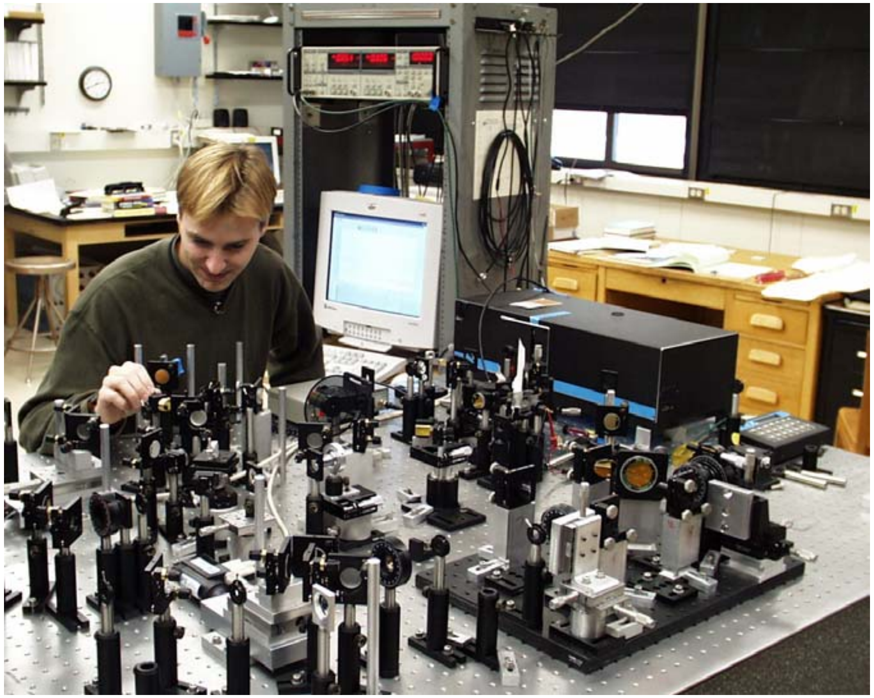

Figure 2. WSU graduate student Aaron Van Pelt sets up a femtosecond pump-probe experiment in the PI's laboratory.